

NEAR-INFRARED (1.0-2.0 MICRONS) GLOBAL IMAGING OF THE MOON. Paul G. Lucey¹, J.L. Hinrichs¹, M.S. Robinson², J. Johnson¹, C.A. Peterson¹, N. Domergue-Schmidt¹, and G.J. Taylor¹. ¹Hawai'i Institute of Geophysics and Planetology, 2525 Correa Rd., Honolulu, HI 96822. ²Norhtwestern Univ., 1847 Sheridan Rd., Evanston, IL 68185.

In support of calibration of the Clementine Near-Infrared Camera, full disk multispectral imaging of the Moon was conducted using the University Of Hawaii Institute for Astronomy QUick InfRared Camera (QUIRC)¹ mounted on a 10 inch telescope piggyback on the UH 60-cm telescope at Mauna Kea Observatory. Images were obtained in 6 wavelengths, five of which are in common with wavelengths obtained by the Clementine mission: 1.0, 1.1, 1.25, 1.50, 1.99, and 2.26 microns. The observations cover 85 degrees of lunar phase and were conducted on the nights of 27 August to 03 September, 1996 UT.

Because the Moon slightly overfilled the field of view of the camera, in order to fill in dead pixels in the focal plane array, to increase signal to noise, and to use a novel flat field technique cited below, many images were obtained of the Moon in each filter with various portions of the Moon centered in the field of view. These filters were then registered and co-added with inoperative pixels discarded. This method left virtually no data gaps (only a few pixels in one mosaic) and approximately 40 images were combined in each of the final mosaics.

The flat field technique employed was described by Kuhn *et al.*². In this method, it is assumed that the target scene and geometry has not changed between measurements, but that the field of view has been translated between observations. Using a set of raw, registered offset corrected images to begin with, it is assumed that the mean of the set of measurements for each point on the target approximates the true value, and that the differences between individual measurements are due to pixel to pixel variations in responsivity (gain). In this iterative method, the set of observations made by each pixel is compared to the mean value of the same locations observed by other pixels, and the gain of the pixel of interest is computed to be that value which adjusts its mean to equal the mean of the observations by other pixels. After 10 or so iterations, the values of the gains for each pixel approach an equilibrium and the process is terminated. The final set of gains is the flat field.

Thus far we have reduced one night of images taken near full moon (8 degrees phase). Inspection of ratio images reveal very clean data with no apparent mosaicking artifacts and no apparent noise relative to lunar color differences. We estimate the SNR of these data to be on the order of 500.

While these images are intended to support Clementine calibration, they are very useful for science in themselves. We controlled and registered these data to the Galileo EM2 data set of McEwen *et al.*³ which was taken and corrected to a

similar viewing geometry. Using the Galileo 756nm data registered to the groundbased data and calibrated to the Apollo 16 landing site spectrum⁴, we constructed images of standard spectral parameters including 1 micron band depth and infrared continuum slope. While many types of analysis can be applied to these data, e.g. the Fischer and Pieters FeO mapping technique⁵, we focused on one simple application.

In the band depth image it is clear that Mare Tranquilitatis is anomalous. Compared to other mare, the depth of the band in the highest Ti regions is on the order of 6-7%. In contrast, basalts in central Serenitatis show band depths on the order of 10-12%. Pieters (1978)⁶ and the Basaltic Volcanism Study Project⁷ both noted the weaker absorption of the presumably sampled mare basalts in this basin based on spectra obtained from the ground of isolated areas in the basin. From "spectral first principles" this weakness is attributed to the masking effect of opaques in the soil or a lower abundance of pyroxene. Upon examination of the difference between low Ti basalts, typified by Apollo 12 basalts, and high Ti basalts returned by Apollo 11 and 17, it is not obvious that pyroxene is less abundant in the high vs. low Ti basalts (Table 1). This might lead a spectroscopist to conclude that masking by opaques is responsible for the attenuated bands of Mare Tranquilitatis. However, Table 1 shows that the iron contents of the pyroxenes of the high Ti basalts are substantially less (averaging about 15wt% FeO) than those of low Ti basalts (averaging about 25 wt% FeO). It seems no coincidence that the FeO content of pyroxenes in high Ti basalts are about 60% of those of low Ti basalts and that the pyroxene absorption features in high Ti basalts are about 60-70% of those of low Ti basalts. It seems a reasonable conclusion that the depth of the 1 micron feature is controlled primarily by the FeO content of the mafic assemblage and that opaques have a secondary effect. This illustrates that the intensity of the 1 micron band is not directly correlated with the mafic nature of an assemblage; rather, it reflects how much total FeO is present in the mafic phase regardless of the abundance of that phase. Mare Tranquilitatis is clearly not less mafic than other mare units.

¹ Hodapp, K. W. *et al*, *New Astronomy*, in press, 1996.

² J.R. Kuhn, H. Lin, and D. Loran, *PASP* **103** pp1097-1108, 1991.

³ McEwen *et al.*, *Proc. 24th LPSC*, p.955, 1993.

⁴ McCord *et al.*, *JGR* **86**, pp10883-10892, 1981.

⁵ Fischer, E.M. and Pieters C.M., *Icarus* **111**, pp475-488, 1994

⁶ Pieters, C.M., *Proc. 9th LPSC*, pp2825-2845, 1978.

⁷ *Basaltic Volcanism Study Project*, 1981.

TABLE 1. ⁸ ⁹ ¹⁰ ¹¹ ¹²

Rock	Ref.	In Avg. Pyroxene		Bulk Rock		Vol% in Rock			
		FeO	TiO ₂	FeO	TiO ₂	ilm	px	ol	plag
12011	8	23.7	1.62	19.3	3.25	2.89	52.9	7.64	30.63
12043	8	25.4	1.14	19.52	3.39	3.45	57.7	0.95	32.82
12007	8	26.6	1.14	17.85	3.82	4.03	48.19	----	39.83
12072	11	25.2	1.38	17.46	1.81	1.15	49.04	5.71	38.94
70215	9	14.2	4.34	17.96	12.59	13.4	57.8	6.1	18.0
71055	9	16.1	2.14	20.13	13.56	16.57	45.66	2.67	27.3
74255	9	14.2	2.35	17.56	12.58	14.5	51.60	3.2	27.6
75055	9	18.7	2.53	17.86	10.48	12.1	50.0	----	32.6
10044	9	15.2	1.71	17.73	10.05	12.2	44.9	----	36.9
10002	10	18.5	1.72	18.22	10.27	12.40	49.53	0.35	31.74
10003	12	20.1	1.41	20.3	10.93	13.28	49.97	0.52	34.18

⁸ Baldrige *et al.*, *Proc. 10th LPSC*, p.141, 1979.
⁹ Dymek *et al.*, *Proc. 6th LPSC*, p.49, 1975.
¹⁰ Beaty *et al.*, *Proc. 10th LPSC*, p.41, 1979.
¹¹ Beaty *et al.*, *Proc. 10th LPSC*, p.115, 1979.
¹² Beaty and Albee, *Proc. 9th LPSC*, p.359, 1978.